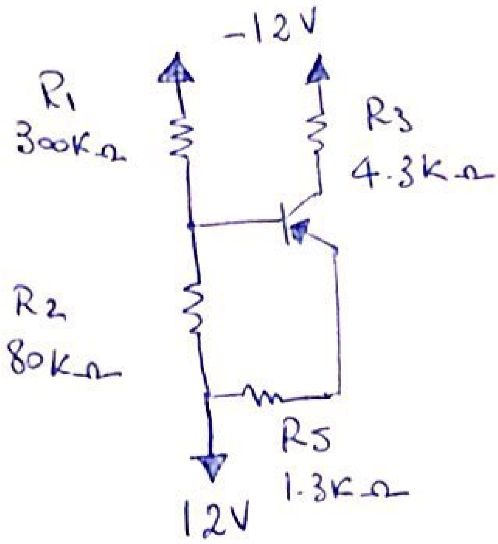
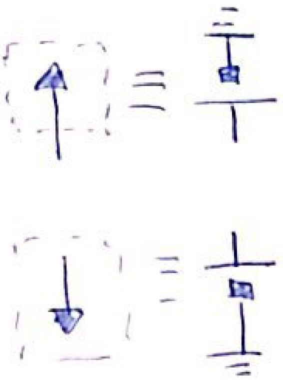
MIDTERM EXAMINATION II - SOLUTION

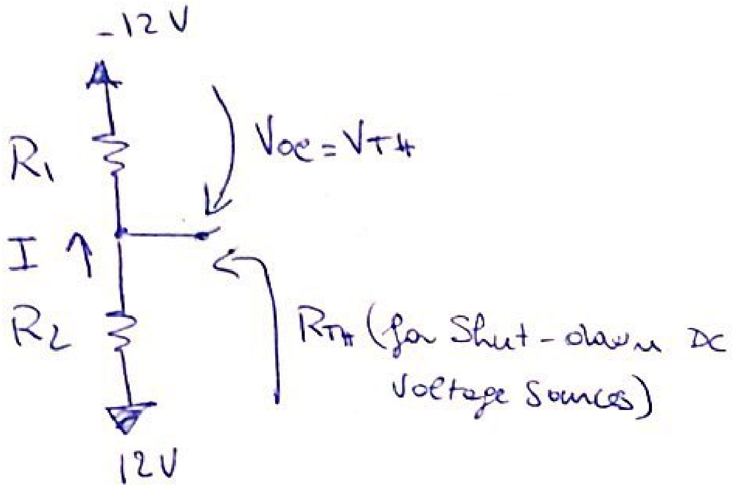
In order to sketch $v_{out}AC$ and $v_{out}DC$, one will have to solve both the DC and the AC (small-signal) version of the circuit.

DC ANALYSIS





It is convenient to reduce the circuit looking away (on left) from the base with its Thevenin equivalent circuit.



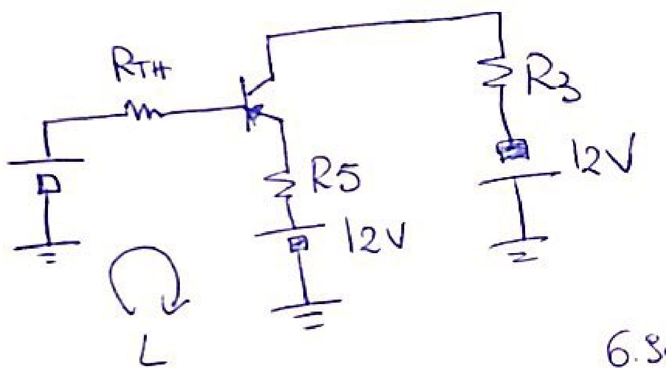
$V_{TH} = -12 + I R_1$

$I = \dfrac{24}{380K} = 63.16\mu A$

$V_{TH} = -12 + 63.16\mu \cdot 300K =$

$= -12 + 18.948 = 6.948\ V$

$R_{TH} = R_1 // R_2 = 300K // 80K = 63.1K\Omega$



KVL @ L:

$V_{TH} + I_B R_{TH} + V_{EB}(on) +$

$+ I_E \cdot R_5 - 12 = 0$

ASSUMING THE BJT IN F-A-MODE:

$I_E = (\beta + 1) I_B$

Thus

$6.94 + I_B \cdot 63.1K + 0.7 + I_B(\beta+1)(1.3K) - 12 = 0$

(2)

$$I_B = \frac{12 - 6.54 - 0.7}{63.1K + (180.7+1)\cdot 1.3K} = \frac{4.36}{299.31} = 14.5\mu A$$

$I_C = \beta I_B = 2.63 mA$; $I_E = (\beta+1) I_B = 2.65 mA$

The next step is to verify the assumption of F.A. mode operation for the BJT.

Since all junctions in the BJT have a threshold (or on) voltage of 0.7V, the condition of active mode operation for the BJT is

$V_{EB} > V_{EB(on)}$ & $V_{BC} < V_{BC(on)}$ with $V_{EB(on)} = V_{BC(on)} = 0.7V$

$V_E = 12 - I_E R_5 = 8.559V$; $V_B = 6.54 + I_B(63.1K) = 7.85V$

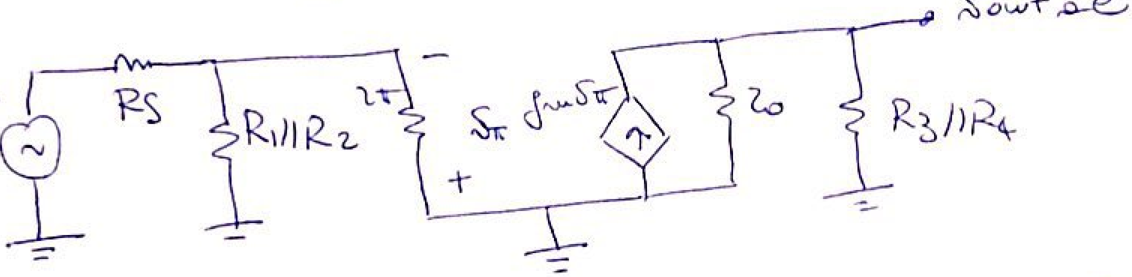
$V = -12 + I_C R_3 = -0.681 V$

$V_{EB} = 0.705 > V_{EB(on)} \Rightarrow$ B-E junction is forward biased.

$V_{BC} = 8.531 > V_{BC(on)} \Rightarrow$ B-C junction is reversed biased.

Thus the assumption of the BJT operating in F.-A. mode is verified.

AC (Small-Signal) analysis.



$$g_m = \frac{I_C}{V_t} = \frac{2.63m}{0.0259V} = 0.101 \frac{A}{V} \;;\; r_\pi = \frac{\beta}{g_m} = \frac{180.7}{0.101} \simeq 1.7 K\Omega$$

$$r_o = \frac{V_{CE} + V_A}{I_C} \simeq \frac{|V_A|}{I_C} \simeq 41.5 K\Omega$$

$v_o = g_m (r_o \| R_3 \| R_4) v_\pi$ $\quad (v_o = v_{out\,ac})$

$$v_\pi = -v_{in} \cdot \frac{R_1 \| R_2 \| R_\pi}{R_S + R_1 \| R_2 \| R_\pi}$$

$$v_{out\,ac} = -g_m (r_o \| R_3 \| R_4) \cdot \frac{R_1 \| R_2 \| R_\pi}{R_S + R_1 \| R_2 \| R_\pi} v_{in} =$$

$$= -0.101 \cdot (41.5k \| 4.3k \| 10k) \cdot \frac{(300k \| 80k \| 1.7k) v_{in}}{20k + 300k \| 80k \| 1.7k} =$$

$$= -\frac{1.731}{21.731} \cdot (283.2) v_{in} = -0.079 (283.2) v_{in} =$$

$$= -22.37 v_{in}$$

$$v_{out\,ac} = v_{in} (-22.37) \text{ V}$$

$$v_{out\,DC} = -22.37 v_{in} + V_C \text{ V} =$$

$$= -22.37 v_{in} - 0.681 \text{ V}$$

Scanned with CamScanner

The VoutDC waveform is identical to the Voutac waveform but it is shifted by −0.681 w.r.t the origin of the voltage axis.